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Monterey, California

THESIS

A COMPARISON OF EFFICIENCY
AND COST-EFFECTIVENESS OF
RADIAC REPAIR FACILITIES

by

Annie L. Pair

December 1985

Thesis Advisor: R. Nickerson

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The data analysis shows the civilian-manned repair facility to be almost twice as productive in output per manhour. The study theorizes that the civilians' level of skill and familiarity with radiacs accounts for their high productivity as compared to the military.

The analysis also finds that civilians are almost three times as efficient in output per constant labor dollar as the military. This is the result of the 50% lower cost per man-hour worked, in combination with their nearly doubled productivity.

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A Comparison of Efficiency and Cost-Effectiveness of Radiac Repair Facilities

by

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ABSTRACT

This ~~study~~ thesis describes the Radiac Program and presents a methodology for examining the productivity and cost effectiveness of two repair facilities, one civilian-manned and the other military-manned. A three-fiscal-year set of summary work data (FY 1980, FY 1981, and FY 1982) was used in the analysis.

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The analysis also finds that civilians are almost three times as efficient in output per constant labor dollar as the military. This is the result of the 50% lower cost per man-hour worked, in combination with their nearly doubled productivity. See p 14

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I. INTRODUCTION

A. PROBLEM

In recent years, the public and private sectors have become increasingly concerned with both efficiency and effectiveness in operations. This concern becomes more significant as operating costs increase and the supporting revenue base remains constant or decreases. Management's major goals for dealing with this situation are maximum effectiveness and maximum efficiency.

Effectiveness is the degree to which an organization attains its objectives. In non-profit organizations such as the Department of Defense, effectiveness cannot be measured in terms of financial data alone as there is no balance sheet or bottom line. If reliable measures of the organization's accomplishments can be found, a comparison of planned and actual output provides a numerical measure of effectiveness [Ref. 1:p. 231].

Efficiency, on the other hand, is the ratio of outputs to inputs, or the amount of output per unit of input. Efficiency conveys the same meaning as productivity. Productivity has acquired many definitions over the years. For instance, it is defined as "the change in product obtained from resources expended" [Ref. 2:p. 3]. The General Accounting Office (GAO) takes a broader approach in defining

productivity to include all measures of efficiency, i.e., output per manhour worked, output per manhour paid, and unit cost [Ref. 3:p. 2].

The literature indicates that the Federal Government began a concerted effort to correlate productivity, productivity measures, and cost savings in the early 1970s. In 1970 GAO, in conjunction with the Civil Service Commission (CSC) and the Office of Management and Budget (OBM), conducted a study to determine if Federal productivity was measurable. The study concluded that productivity of the workforce could be measured, and that the resulting data could be useful in manpower forecasting, manpower utilization, and budget formulation [Ref. 3:p. 2].

In 1972 the Naval Personnel Research and Development Laboratory published a model for measuring productivity trends at naval shore activities [Ref. 4]. This document provided the Navy manager with a tool for measuring productivity at all military levels in the command. Though tailored with the military in mind, the concepts could readily be applied to the civilian workforce since maximum efficiency is an objective the total workforce should strive to achieve.

The results of the initial studies generated considerable interest on the behalf of the Federal Government in productivity measurement. It became apparent to the Federal Government that such data collected at regular intervals

could become a very important management tool. The collection and subsequent analysis of these data could provide the nation's leaders with current information on the workforce's productivity. To ensure the availability of data, the Bureau of Labor Statistics (BLS) has compiled and published a general indicator for the Federal Government and selected industires for many years. In addition to the efforts of the BLS, the United States Office of Personnel Management (OPM) in 1980 directed the Workforce Effectiveness and Development Group (WED), a subunit of OPM, to conduct ongoing research on ways to improve and measure productivity [Ref. 5:p. 13].

It was this type of interest in cost-effectiveness and productivity that led some of the officials within the Naval Electronic Systems Command (NAVELEX) headquarters to look at areas which were appropriate for a management study. One such area which was considered and subsequently pursued was the Radiac Repair Program. Over the last few years operating costs had been increasing and only some of the increase was attributable to normal cost growth, (i.e., inflation). It was thought that the unexplained growth could be the result of inattentiveness to cost-effectiveness practices or reduced productivity.

It is with this problem of unexplained cost growth within the Radiac Repair Program that this thesis is concerned. Due to the extent of the program and the number of facilities involved it was beyond the scope of this thesis to

attempt a comprehensive analysis of the entire program. The analysis is limited to the problem of comparing the relative productivities of civilian vs. military repair personnel within the Radiac Repair Program.

B. OBJECTIVE

This study will analyze and compare the effectiveness and efficiency of operations of the Radiac Repair Facility, Washington, DC and the Ship Repair Facility (Radiac Repair section) Rota, Spain. As neither is a profit-making entity the major thrust will be on the labor cost incurred for operations, and the level of output produced based on the resources applied. The objective of this study is to determine if it is more cost-effective to man radiac repair facilities with civilian personnel or military personnel, in terms of actual labor dollar expenditures and productivity levels.

C. RESEARCH METHODS

1. Data

The Radiac Repair Facility (RRF) in Washington, DC was chosen as a typical civilian-manned facility and was used as the data sample for the analysis of such activities. The Radiac Repair Facility in Rota, Spain--the only RRF wholly manned by military personnel--was used as the data sample for military-manned activities. The analysis was conducted on quarterly summary data for fiscal years 1980 through 1982 from these two RRFs. The data analyzed in

this study includes the number of personnel at each RRF, the quarterly output of radiac units calibrated, and the number of manyears of effort and labor cost it took to calibrate the radiacs.

2. <u>Data Sources</u>

Commander, Naval Electronic Systems Command (NAVELEX 8753) supplied the radiac maintenance workload quarterly reports for the Rota and Washington facilities. A sample of these quarterly reports is included as Appendix B. Relevant data extracted from the quarterly reports of the two facilities for the sample period FY 80-FY 82 is summarized in Appendix C. Several interviews were conducted with personnel in the Radiac Program to obtain pertinent background information and an outlook for the future.

D. THESIS ORGANIZATION

Chapter II describes the Radiac Program and provides background information on the operation of Radiac Repair Facilities.

Chapter III analyzes the productivity of workers at the two facilities. It discusses the differences found in the level of productivity for the two workforces and presents some possible explanations for the differences.

Chapter IV analyzes the cost data of the two facilities in both current dollars and constant dollars. The cost per unit output is calculated and compared for the two facilities.

Chapter V presents a summary of the conclusions of this study and recommendations for future research.

II. BACKGROUND INFORMATION

A radiac is an apparatus for detecting and measuring nuclear radiation. The acronym "RADIAC" stands for RAdio-active, Detection, Identification, And Computation. The Radiac Program is concerned with all matters dealing with radioactive detection and measurement. The primary considerations of the Radiac Program are safety, emergency preparedness, and adherence to pertinent government regulations.

A. THE RADIAC PROGRAM

The United States Navy's Radiac Program is sponsored by the Commander, Naval Electronic Systems Command Headquarters (NAVELEX). It is under the guidance of this major naval command that the program is managed and equipment procured. NAVELEX has the responsibility for radiac equipment "from the cradle to the grave" which includes allowance administration, budgeting, procurement, maintenance, and calibration. The administrative responsibilities of managing this functional area are resident in the Nucleonic Branch of NAVELEX. The Key responsibilities of maintenance, calibration, and allowance actions (recommendations for approval of requests for radiac equipment) are delegated to ten Radiac Coordinators. These Coordinators are physically located at six NAVELEX field activities, three naval shipyards and one other naval activity. Each Radiac Coordinator is assigned

a geographical area or areas of responsibility for which service must be provided. A listing of the locations of Radiac Coordinators and their areas of responsibility is presented in Appendix A.

The Navy operates nineteen repair facilities for the maintenance and calibration of radiacs. Each facility is designed to meet the specific requirements assigned to it. That is to say, the size and capacity of the facility are commensurate with the overall number of radiacs assigned for servicing.

B. PERSONNEL

Seventeen of the nineteen repair facilities are entirely manned by civilian government employees. One repair facility has a mixture of civilian and military manning. The final facility is completely manned with military personnel. All personnel are either electronic technicians or electronic mechanics. On the average, civilian employees have more than ten years of experience in the repair facilities. Military personnel have less work experience with radiacs because they are totated to and from duty stations in which they perform maintenance and repair duties on other kinds of equipment than radiacs.

C. FUNDING

The Radiac Program is fully funded by NAVELEX for routine maintenance, repair, and calibration services for

NAVELEX-approved-allowance equipment used for operational and disaster preparedness purposes. Civilian-manned repair facilities receive Operation and Maintenance, Navy funds (O&MN) to support operation costs. Funds from the O&MN account cover civilian labor cost, material costs, and any commercial support contracts that exist. Military-manned repair facilities receive O&MN money to pay for the above types of expenses, but the major costs of the military labor are paid from a different appropriation acocunt: Military Personnel, Navy (MPN). All costs for the civilian-manned facilities are reported quarterly to NAVELEX on the "radiac maintenance workload reports". In the case of the military-manned repair facility, the only cost reported to NAVELEX is material as all labor costs are charged to MPN.

D. EQUIPMENT

A substance is said to be radioactive when it gives off or has the capacity for giving off, radiant energy in the form of particles or rays, as alpha, beta, and gamma rays by the disintegration of atomic nuclei [Ref. 6:p. 36]. Each of these types of radiation have different properties, thus requiring different equipment for detection and accurate measurement. NAVELEX issues a broad array of survey meters, laboratory equipment, monitoring systems, dosimeters, calibrators, and other radiacs for detecting and measuring ratiation in the work space and environment.

E. MAINTENANCE, REPAIR AND CALIBRATION

A policy for routine maintenance of all radiac equipment has been established by NAVELEX. It prescribes standards for the minimum maintenance necessary to keep the equipment in satisfactory operating condition. To insure that all equipment is kept at operational readiness, the Radiac Coordinator must develop maintenance schedules and inform all user activities under his cognizance as to when their equipment must be serviced. NAVELEXINST 9673.5D states that portable radiac equipmen: should be calibrated at six month intervals, however, the instruction also delineates several exceptions to the six month interval. Those equipments listed as exceptions have calibration intervals of one to two years or as directed by NAVELIX [Ref. 7:p. 15]. Since it is not operationally sound to remove all of an activity's equipment at once, NAVELEX recommends that one half of the allowance be turned over to the repair facility every three months [Ref. 8:p. 27]. This also helps give a more even distribution of the workload at the facility throughout the workyear. Workload distribution is a major concern of the Radiac Coordinator, who has the responsibility of meeting all regularly scheduled requirements as well as providing emergency repair and calibration service upon request [Ref. 8:p. 28].

The normal procedure for maintenance and calibration of a radiac consists of several steps. Upon receipt of a

radiac the outer case is wipe-tested for radiation contamination before the radiac is brought to the work area. The radiac is checked for electronic and mechanical deficiencies; if any are found, the unit is repaired. Various checks are made to see if the radiac is within acceptable tolerance limits for accuracy. If it is found to be out of tolerance it is recalibrated. Batteries are tested and replaced when necessary. Once the radiac is repaired and calibrated, it is ready for return to the user activity.

F. ALLOWANCE

Radiac equipment is obtained by the end-user (Customer) through the establishment of an allowance. There are two basic equipment allowances in the radiac program: operational use (OU) and disaster preparedness (DP). An operational use radiac is one used in day-to-day radiological working and training. The disaster preparedness radiacs are those designated for emergencies. Requests for OU allowances originate with the requesting activities and are sent via the Radiac Coordinator to NAVELEX. The Radiac Coordinator endorses such requests and comments on the technical requirements of the requested equipment. A request must include the equipment category, equipment nomenclature, present allowance, and a complete justification of the need. Approval of an OU allowance is based on the assigned responsibilities of the requestor: radiography, weapons handling, or industrial hygiene [Ref. 8:p. 16].

Once an OU allowance is approved, NAVELEX issues radiac equipment to the requestor. After receiving the equipment, the end-user is required to provide the Radiac Coordinator with an updated listing of equipment held. This listing is used for scheduling maintenance and calibration.

In the case of the disaster preparedness allowance, the request originates with the Disaster Preparedness Force Commander, who also must send the request through the Radiac Coordinator. The Radiac Coordinator completes the "Shore Radiac Equipment Allowance" form indicating the number of disaster preparedness teams and equipment desired. This form is forwarded to Naval Electronic Systems Engineering Center, Charleston (NESEC Charleston) for action. NESEC Charleston determines the number of radiacs to be authorized. The disaster preparedness request is then approved and filled in accordance with priorities established by the Chief of Naval Operations [Ref. 8:p. 20]. The remaining procedures for accountability and maintenance scheduling are the same as those of the operational use equipment.

III. PRODUCTIVITY

This chapter deals with the impact of labor productivity on output. The collected data will be analyzed to see if there is a significant difference between the productivity for the civilian-manned RRF (Washington) and the military-manned RRF (Rota).

The analysis will be based on the principles of the production function. A production function is a model which shows the relation between inputs and outputs. It takes the form of

$$Q = f(K,L)$$

where Q represents the output of a particular good during a period, K represents the capital used during the period, and L represents hours of labor input [Ref. 9:p. 133].

For this study capital is assumed to be constant for all observations, both over time and between the two facilities. Labor is that input provided by the employees of the facilities. It is assumed that only the labor input is variable over the observations. The measurable output, Q, is the number of radiacs calibrated. The output and input elements will be considered individually later in this chapter.

Before analyzing labor productivity for each of the facilities, it is necessary to establish a definition of labor

productivity. Economists define labor productivity as "measures of output obtained from inputs of labor." [Ref. 9: p. 133] So in essence, this chapter is concerned with determining how output varies compared to the available labor input.

A. UNITS OF OUTPUT

For the purposes of this analysis, the units of output in a RRF are calibrated radiacs. NAVELEX specifies that the various equipments be converted to "standard calibration units" as follows [Ref. 10]:

1. Ratemeter and detector calibrations equal one calibration unit.
2. Five dosimeter charger calibrations equal one calibration unit.
3. Fifty dosimeter calibrations equal one calibration unit.

Each RRF uses these predetermined standards to compute total calibration units. These calibration units are then summed for all the equipment serviced to arrive at the quarterly output data that is reported by the RRFs to NAVELEX.

Output in standard calibration units for the twelve quarters in FY80-FY82 appears in Table 3-1 for the Washington and Rota RRFs. This data is also presented graphically in Figure 3-1 to display the fluctuations in output.

TABLE 3-1

OUTPUT FOR FY 8Ø-82
(STANDARD CALIBRATION UNITS)

Quarter	RRF Washington	RRF Rota
1 Oct-Dec 1979	4ØØ	122.36
2 Jan-Mar 198Ø	437	113
3 Apr-Jun 198Ø	428.5	2Ø1
4 Jul-Sep 198Ø	376	171
5 Oct-Dec 198Ø	283.5	168
6 Jan-Mar 1981	5Ø4	93.6
7 Apr-Jun 1981	5Ø1	173
8 Jul-Sep 1981	4ØØ	153
9 Oct-Dec 1981	364	152.5
10 Jan-Mar 1982	387	122.7
11 Apr-Jun 1982	592	2ØØ
12 Jul-Sep 1982	47Ø	171.2
Mean	428.6	153.5

Source: Radiac Maintenance Workload Reports

B. UNITS OF INPUT

The input variable which this study examines in detail is direct labor, in units of man-hours of effort provided by the available personnel. The RRF Washington had a constant four employees during the period of FY8Ø-FY82 while the RRF Rota had an average of 2.42 employees for the same time period.

The Washington facility had located on its premises the area Radiac Coordinator who was not counted as part of the facility manning for the purpose of this study. During the first four quarters (FY 198Ø) of the sample, there were five employees assigned to the Washington facility, one of whom was the Radiac Coordinator. Cost for the Coordinator was not included but was considered as overhead. The

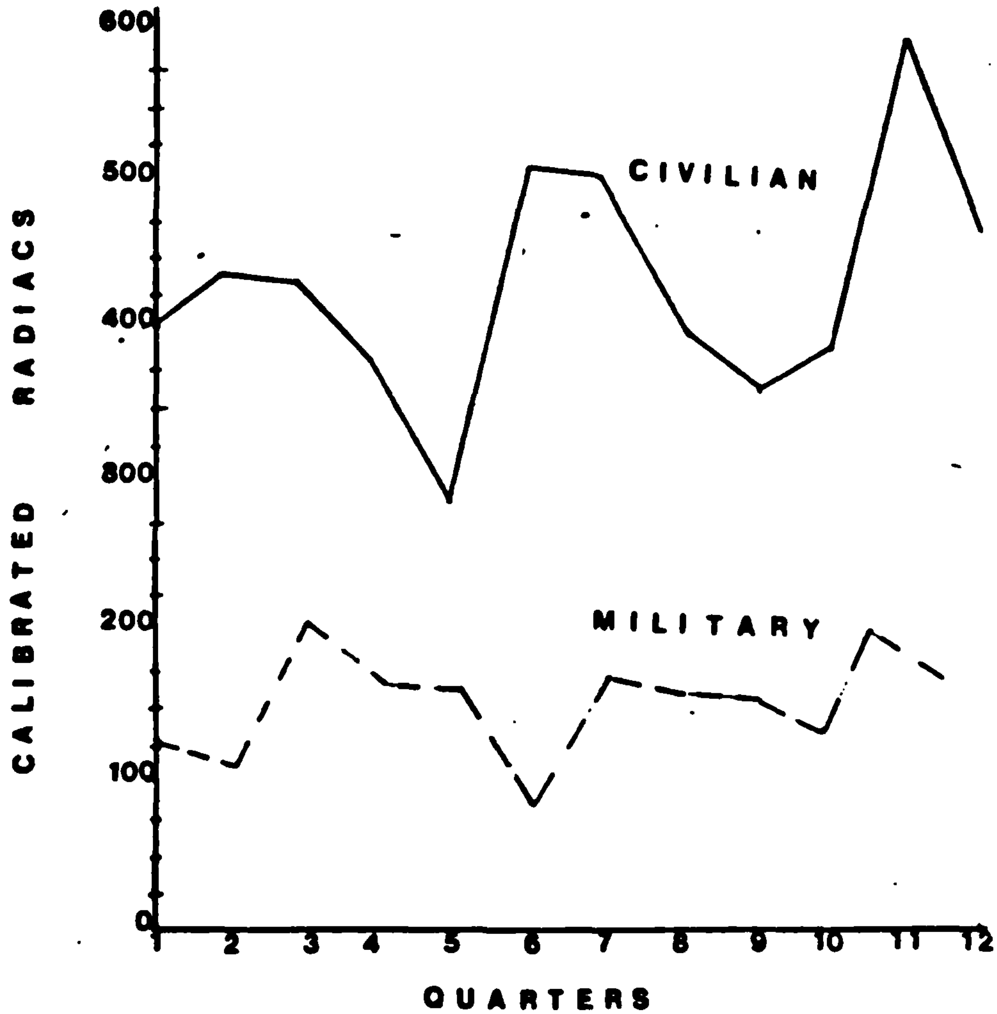

Figure 3-1 Output per Facility

The Coordinator retired the second week of the fifth quarter of the sample period. One of the RRF line technicians subsequently assumed the duties of Coordinator but also continued working as a line technician. Thus the RRF manning was considered by this analysis as constant at four employees throughout the period covered in this study.

The Rota facility had two technicians assigned for the first seven quarters of the sample period. One technician was added in the eighth quarter. Rota remained staffed with three technicians for quarters nine through twelve. There were changes in the grades of personnel assigned to Rota, however, this information was considered only in deriving cost which is discussed later. For the purpose of this chapter only the quantity of labor input in man-years or man-hours is analyzed. The possible qualitative effects of paygrade, seniority, or experience on productivity were not analyzed.

The input data used in this study came from the Radiac Maintenance Workload Reports (Appendix B) and NAVELEX internal summary sheets [Ref. 11]. The Radiac Maintenance Workload Reports submitted by RRF Washington report the actual effort in man-years utilized each quarter to produce the output. These data reflect actual, recorded man-hours of labor, converted to man-years before reporting by a conversion factor of 2080 man-hours per man-year [Ref. 12].

The RRF Rota did not report man-year data on the Radiac Maintenance Workload Reports as it did not have to account to NAVELEX for labor cost. However, to maintain consistency in record keeping and to aid in tracking trends for each of the facilities, NAVELEX assigned man-year statistics to this facility based on the actual onboard count of personnel. NAVELEX assumed that one-fourth of a man-year was worked each quarter per person as noted on the internal summary sheets. So, if there were two persons manning the RRF in a given quarter, the effort for that quarter was recorded by NAVELEX as .5Ø man-year. Thus, man-year data for military labor at the Rota RRF was strictly an estimate generated at NAVELEX headquarters.

Clearly the methods employed for determining and reporting man-year data for the two facilities presented a problem in conducting a comparison of the productivity of the two facilities. Since the resulting data was not strictly comparable, it was necessary to develop conversion factors to bring the repair facilities' data more in line with each other.

In order to alleviate the dissimilarities in the reported data, the "Manual of the Navy Total Force Manpower Policies and Procedures," OPNAVINST 1ØØØ.16E, were used. This was chosen as a definitive source because it contains information on the number of hours which the Navy recognizes as making up a standard workweek for both shore based civilian

and military personnel. From this model for a standard workweek, the information could be expanded to arrive at a conversion factor between man-years and man-hours.

A standard workweek for shore-based civilian and military personnel is taken to be five eight-hour days. This forty hour workweek gives a 2080 hour man-year (52 weeks x 40 hours). This figure of 2080 hours is the conversion factor for a standard man-year [Ref. 13].

However, this factor actually represents the number of work-hours available for labor by one worker in a year without overtime. Obviously, some time can not be spend in production. In order to estimate the number of man-hours of production time in a year, average times can be subtracted from the forty-hour base for training, diverison, leave, and holidays. This was done in the OPNAV model, which gave estimates for an average productive week of 33.38 man-hours for civilian personnel and 31.94 man-hours for military personnel [Ref. 13].

The details of the OPNAV model are shown in Table 3-2. Assuming a 52 week work-year this model yields an estimate of 1736 productive man-hours and 344 non-productive man-hours for civilian personnel. This information will be used later in Chapter III in the productivity comparison between the civilians and military.

The model yields 1661 productive man-hours per year for military personnel. The remaining 419 man-hours of the

TABLE 3-2

OPNAV STANDARD WORKWEEK

		CIVILIAN	MILITARY
STANDARD WORKWEEK		40.00	40.00
less:	Training	.20	1.83
	Diversion*	.44	3.00
	Leave	4.60	1.85
	Holidays	1.38	1.38
Total Time Available for Productive Work		33.38	31.94

Source: OPNAVINST 1000.16E

*Diversion is defined as military requirements which are placed upon military personnel as a result of military routine or regulations and includes quarters, inspections, sick call, payline, haircuts, business at the post office, ship's store, and business at personnel and disbursing. Diversion for civilians covers similar administrative functions.

standard 2080 hours man-year are used for non-productive activities. One must bear in mind that this can be an inaccurate estimate because the military workweek may exceed the standard forty-hours. This model was used to estimate the input man-hours of labor for the military-manned facility.

The initial step in preparing the data for a comparison analysis was the conversion of the reported man-year data to man-hours. This information is reflected in Tables 3-3 and 3-4. In these tables are shown by quarters, the number of technicans, reported and/or estimated man-years, and standardized or adjusted estimates of man-hours of labor performed. The man-year data was that recorded by the

TABLE 3-3

CONVERSION OF REPORTED CIVILIAN MAN-YEAR DATA TO MAN-HOURS
(RRF WASHINGTON)

QTR	TECHNICIANS	REPORTED MY	STANDARDIZED MH	ADJUSTED MH
1	4	.74	1539	1736
2	4	.75	1560	1736
3	4	.74	1539	1736
4	4	.62	1290	1736
5	4	.98	2038	1736
6	4	.96	1997	1736
7	4	.68	1414	1736
8	4	.67	1394	1736
9	4	.63	1310	1736
10	4	.63	1310	1736
11	4	.69	1435	1736
12	4	.61	1269	1736
MEANS	4	.73	1508	1736

SOURCE: RADIAC MAINTENANCE WORKLOAD REPORTS AND OPNAVINST 1000.16E

LEGEND: TECHNICANS (NUMBER ASSIGNED PER QUARTER)
REPORTED MY (REPORTED MAN-YEARS)
STANDARDIZED MH (STANDARDIZED MAN-HOURS BASED ON 2080 ANNUAL MAN-HOURS/REPORTED MAN-YEAR)
ADJUSTED MH (ADJUSTED MAN-HOURS BASED ON 1736 ANNUAL MAN-HOURS/AVAILABLE MAN-YEAR)

TABLE 3-4

CONVERSION OF ESTIMATED MILITARY MAN-YEAR
DATA TO MAN-HOURS
(RRF ROTA)

QTR	TECHNICIANS	ESTIMATED MAN-YEARS	ADJUSTED MAN-HOURS
1	2	.5∅	831
2	2	.5∅	831
3	2	.5∅	831
4	2	.5∅	831
5	2	.5∅	831
6	2	.5∅	831
7	2	.5∅	831
8	3	.75	1246
9	3	.75	1246
1∅	3	.75	1246
11	3	.75	1246
12	3	.75	1246
MEANS	2.42	.6∅	1∅∅4

SOURCE: RADIAC MAINTENANCE WORKLOAD REPORTS AND NAVELEX INTERNAL WORKSHEETS

LEGEND: ADJUSTED MAN-HOURS (BASED ON 1661 ANNUAL MAN-HOURS/ ESTIMATED MAN-YEAR)

repair facility (for civilians) or estimated by NAVELEX (for military). Standardized man-hours were those man-hours estimated from the man-year data using the conversion factor of the standard 2∅8∅ man-hours per man-year. Adjusted man-hours reflect the standard 2∅8∅ man-hours available adjusted (as in the OPNAV model) for non-productive time. The conversion factor for military technicians was 1661 man-hours per man-year; for civilian technicians it was 1736 man-hours per man-year.

The reported civilian man-year data as it appeared on the Radiac Maintenance Workload Reports already reflected time off for leave, holidays, and other diversion time. This

indicated the most appropriate factor for conversion should be the standard man-year of 2080 man-hours. The product of the man-year data recorded on the Radiac Maintenance Workload Reports and the man-hours per standard man-year conversion factor should give the most accurate estimate available of actual labor input for the civilian force. However, data similar to this was not available for the military. In order to have comparable data for each facility a second estimate of civilian labor input was made, although it was recognized this could be less accurate than the "standard" estimate. An adjusted man-hours estimate was made for the civilian facility by multiplying the available man-years (0.25 man-years per quarter per civilian technician assigned) by the OPNAV conversion factor of 1736 man-hours per year.

The military data available had not been adjusted in any way. It simple reflected man-years of labor available (0.25 man-years per quarter per technician assigned). The best estimate of labor input that could be made with this data was the adjusted man-hours estimate made by multiplying the labor available by the OPNAV adjusted conversion factor of 1661 man-hours per man-year.

C. PRODUCTIVITY ESTIMATES

The standardizations of output and labor in the previous two sections served as the framework for determining the productivity estimates discussed in this section.

Productivity was estimated by dividing the standardized quarterly output as described in Section A by the estimated direct labor input for that quarter using the data and model described in Section B. The formula used to compute output per man-hour was:

$$\text{Productivity} = \frac{\text{Standardized Output (Calibrations)}}{\text{Estimated Labor Input (Man-Hours)}}$$

The results obtained from this computation are the productivity data which were obtained by dividing the output, in "standardized calibration units," by either the standardized or the adjusted labor inputs (converted to man-hours by one of the factors described earlier).

Table 3-5 contains information about the Washington facility. Included are the quarterly unit output and the standardized man-hours input, along with the resultant productivity.

TABLE 3-5

CIVILIAN OUTPUT PER STANDARDIZED MAN-HOUR

QTR	OUTPUT	STANDARDIZED MAN-HOURS	PRODUCTIVITY
1	400	1539	.26
2	437	1560	.28
3	428.5	1539	.27
4	376	1290	.29
5	283.5	2038	.14
6	504	1997	.25
7	501	1414	.35
8	400	1394	.29
9	364	1310	.28
10	387	1310	.30
11	592	1435	.41
12	470	1269	.37
MEANS	428.6	1508	.29

LEGEND: QTR (QUARTERS AS DEFINED IN TABLE 3-1)
OUTPUT (STANDARD CALIBRATION UNITS FROM TABLE 3-1)
STANDARDIZED MAN-HOURS (FROM TABLE 3-3)

Table 3-6 contains data similar to that of Table 3-5. The difference is the basis for the estimated labor man-hours. In the preceeding table, civilian labor input was estimated using the standard man-year of 2080 man-hours. In Table 3-6, civilian labor input estimates were based on the adjusted man-hour model described in the preceeding sections.

TABLE 3-6

CIVILIAN OUTPUT PER ADJUSTED MAN-HOUR

QTR	OUTPUT	ADJUSTED MAN-HOURS	PRODUCTIVITY
1	400	1736	.23
2	437	1736	.25
3	428.5	1736	.25
4	376	1736	.22
5	283.5	1736	.16
6	504	1736	.29
7	501	1736	.29
8	400	1736	.23
9	364	1736	.21
10	387	1736	.22
11	592	1736	.34
12	470	1736	.27
MEANS	428.6	1736	.25

LEGEND: QTR (QUARTERS AS DEFINED IN TABLE 3-1)
OUTPUT (STANDARD CALIBRATION UNITS FROM TABLE 3-1)
ADJUSTED MAN-HOURS (FROM TABLE 3-3)

Table 3-7 shows corresponding information for the Rota facility. As noted earlier, actual military productive labor was not recorded; only adjusted man-hour estimates based on total labor available for productive work can be made for the Rota facility. Table 3-7 reflects this data.

The productivity estimates from Tables 3-5, 3-6 and 3-7 are displayed graphically in Figure 3-2.

TABLE 3-7

MILITARY OUTPUT PER ADJUSTED MAN-HOUR

QTR	OUTPUT	ADJUSTED MAN-HOURS	PRODUCTIVITY
1	122.3	831	.15
2	113	831	.14
3	2∅1	831	.24
4	171	831	.21
5	168	831	.2∅
6	93.6	831	.11
7	173	831	.21
8	153	1246	.12
9	152.5	1246	.12
1∅	122.7	1246	.1∅
11	2∅∅	1246	.16
12	171.2	1246	.14
MEANS	153.5	1∅∅4	.16

LEGEND: QTR (QUARTERS, AS DEFINED IN TABLE 3-1)
OUTPUT (STANDARD CALIBRATION UNITS FROM TABLE 3-1)
ADJUSTED MAN-HOURS (FROM TABLE 3-4)

It is clear from Figure 3-2 that civilian productivity, by either standardized or adjusted estimate, was higher than military productivity in 11 of the 12 quarters. Only in quarter 5 of the sample (Oct-Dec 198∅) did military productivity exceed that of the civilian workforce. (It was in this quarter that the civilian-manned RRF Washington recorded both its lowest output of units calibrated and its highest input of reported labor. The reasons for this atypical activity at RRF Washington were not recorded on the Radiac Maintenance Workload Report.) In fact, except for quarters three through five (Apr-Dec 198∅), civilian productivity by either estimate was very substantially greater than that of the military: approximately double. Over the

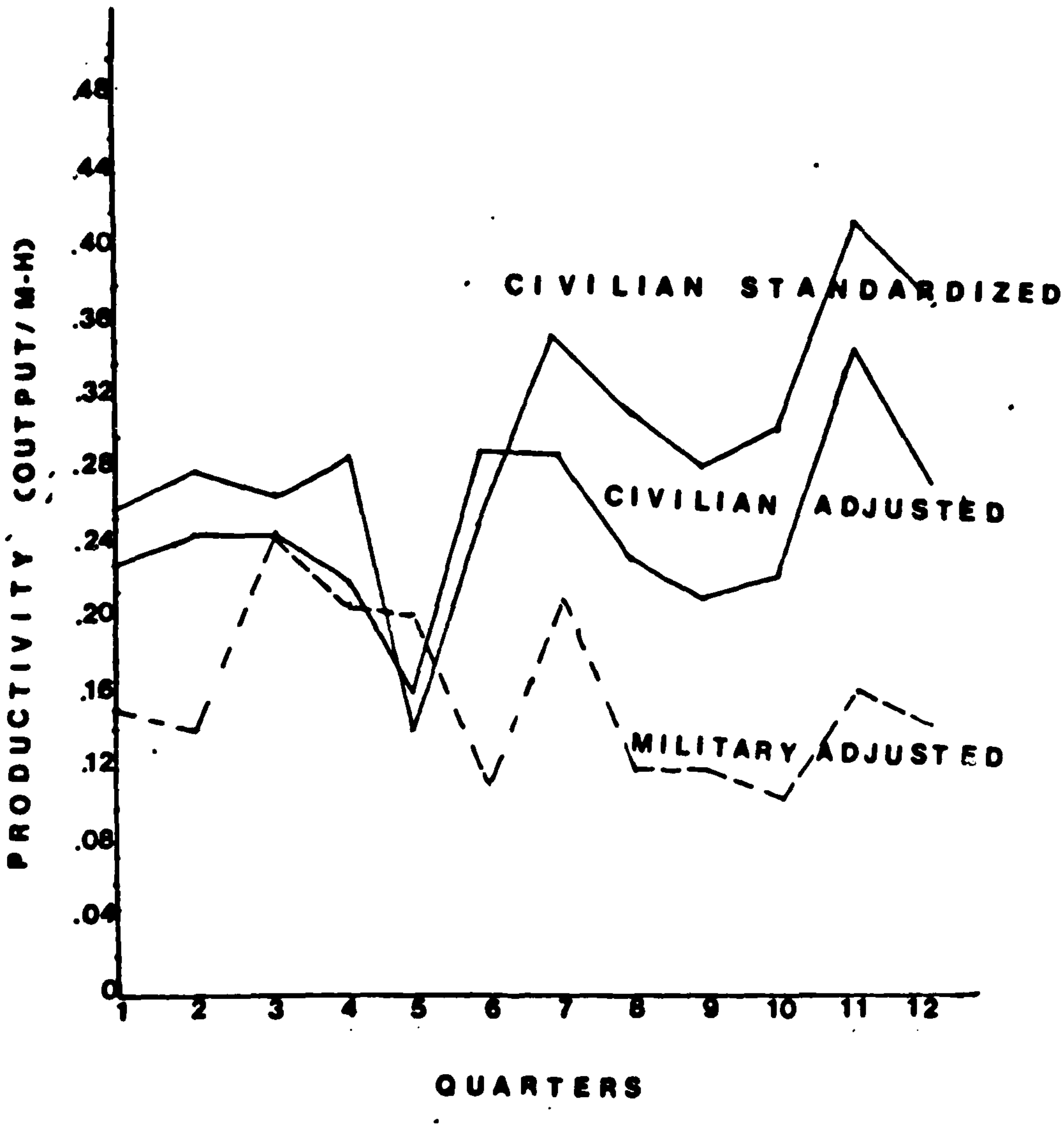

Figure 3-2 Average Productivity

entire 12 quarters of the sample, civilian productivity was estimated at either .29 units/man-hour (standardized) or .25 units/man-hour (adjusted). The adjusted estimate of military productivity over the whole sample was .16 units/man-hour.

It is conclusive from the above that the civilian force had higher productivity than did the military labor force. The general factors that may have had an influence on this difference are discussed in the next sections.

D. THE WORKFORCE

In Section C approximately a two-fold difference in the productivity level was observed between the civilian and military workforces. This seemed to be quite a disportionate difference because each workforce was staffed with trained electronic technicians. One of the most likely explanations for this variance rests in the relative skill and familiarity with the equipment: the familiar "learning curve" phenomenon.

The civilian personnel at the Washington facility had worked an average of fifteen years in the Radiac Program. In contrast, though they had a good general background and experience in electronics and electronic equipment, the military personnel generally only had performed duties at a radiac repair facility for two to three years. Unlike the civilian personnel, the military were subjected to periodic duty station rotations; therefore, much of their expertise was in repairing and maintaining other types of electronic equipment than radiacs.

It would be expected that upon a military technician initially being assigned to an RRF, productivity would be lower until the sailor became familiar with the work. The data analyzed did not indicate which stage of their tours that military personnel were in when the data were collected, although all the military clearly had much less RRF experience than the civilian average of fifteen years.

This wide diversity in level of experience between the two labor forces suggests that the principles of specialization of labor and the learning curve may have been factors that had a significant influence on the observed productivities.

It is also the case that "productive work" for military members is often interpreted by their commands to be any military duty, a matter not addressed by the OPNAV model [Ref. 13]. Thus, while a civilian technician is rarely tasked to anything other than the productive work for which he is hired, with associated setup and cleanup (and the "diversion" activities addressed by the OPNAV model), a military member may (aside from "diversion") be assigned to watch, shore patrol, mess cook, security, etc., duties over an extended period in place of his nominal "productive" duties. This also may have had a significant impact.

E. WORKLOAD

No detailed data on the facilities' workloads were available from the collected data. The available workloading

data were reported as quarterly summaries only with no indication as to the average daily or weekly throughput, nor of the levels of inventory of work accepted but not begun.

The Washington facility primarily serviced shore activities in the Naval District Washington area. Possessing general information as to the allowance of each activity, the repair facility could schedule the induction of radiacs to maximize the use of its available manning. Inventory could be stockpiled to ensure that there was a steady flow of work. Having scheduling flexibility provides the opportunity for more efficiency in operation.

Compared to Rota RRF, the more routine nature of the work, predictability of demand and possibility of inventorying work accepted gave the Washington facility much more of an opportunity to process similar types of radiacs in batches according to economic lot sizes.

The Rota repair facility's primary customers were ships and aircraft squadrons, most of which were only in Rota for brief periods. Even though the facility may be privy to the number and types of radiacs a particular ship class is authorized to have onboard, it would have no further detail available for advanced planning. The tendency of ships to operate together in Task Units would work against being able to even out the workload. Because of the immediacy imposed by ship movements, it would be quite difficult for Rota to maintain even workload levels to ensure the most efficiency

for the resources invested. Compared to Washington, it is likely the Rota workloading was characterized by much more severe peaks and valleys. Also, since Rota was dealing with operating ships and aircraft, Rota's work was likely to have been done more urgently, with less allowable processing time than was Washington's. It is therefore unlikely that Rota could have made significant use of economic lot size planning. Finally, because of the relative urgency of the work, Rota may have been staffed at a level determined more by the peaks in loading than by considerations of overall operating efficiency.

For these reasons, the Washington facility would have more opportunity to maximize efficiency than the Rota facility.

F. SUMMARY

This chapter has presented a basic analysis of the productivity levels of the civilian and military personnel. It has revealed a nearly two-fold difference in productivity for the two workforces. That is to say, the civilian personnel were almost twice as productive as the military personnel.

In the next chapter this productivity information will be combined with labor cost data to address the relative cost efficiency of the two facilities.

IV. COSTS AND COST COMPARISONS

This chapter discusses the labor costs associated with the operation of the repair facilities. The analysis looks at how labor cost is derived for each workforce--civilian and military. The labor cost is standardized and converted to constant dollars. Finally, a unit cost comparison of the two facilities is made.

A. DESCRIPTION

The cost data used in this study were obtained from two sources. Civilian labor cost data were extracted directly from the Radiac Maintenance Workload Reports. These data were expressed in current dollars and included overhead cost elements such as leave pay, holiday pay, retirement, and insurance. Since no labor cost data was reported for the military, it was necessary to derive a cost. Military labor cost, in current dollars, was determined from manning levels reported by the facility through the use of the Life Cycle Navy Enlisted Billet Costs model [Ref. 14]. This model includes base pay, the amortized selective reenlistment bonus (SRB), proficiency pay, hazard pay, sea pay, variable housing allowance (VHA), retirement, separation pay, accession, training, and undistributed costs over the life cycle of the billet.

B. CURRENT DOLLAR VS CONSTANT DOLLAR

The current dollar is "an expression reflecting actual prices of each year", whereas the constant dollar is "an expression reflecting the actual prices of a previous year or the average of actual prices of a previous period or years" [Ref. 15:p. 685]. Economists use the constant dollar concept to compensate for the effects of inflation. To calculate costs in constant dollar amounts, an index is computed. The index discloses relative changes in a series of numbers such as labor cost from a base period. The base period is assigned an index number of 1.00. All other index numbers in the series, both before and after the base period, reflect the ratio of prices in that period to prices in the base period [Ref. 15:p. 392].

Before proceeding with the computation of the labor cost index, it was necessary to establish a base cost for the civilian and military workforces to normalize cost for further analyses. The civilian paygrades at the Washington facility during the period of this study were GS-11/5, GS-10/5, GS-8/5, and GS-2/3. In order to arrive at an average paygrade representative of the workforce, the annual salaries of the individuals were computed and the resulting average was commensurate with that of a GS-8/1. The annual salary of a GS-8/1 was used to construct the index of civilian pay for this analysis.

Unlike the paygrades of the Washington facility, which remained constant, the workforce at the Rota facility varied over the period of time covered in this study. Paygrades from E-4 to E-9 were present at Rota. To determine the average paygrade, the base pay for those paygrades onboard were used. Since the data did not indicate longevity, the minimum longevity for each paygrade was assumed. The average representative paygrade was determined to be an E-6 (over 6). The base pay for this paygrade was used to calculate the index of military pay for this analysis.

The labor cost index was computed by dividing the selected average paygrade salary in each quarter by the same average paygrade salary for the first quarter. Table 4-1 shows the labor price indices for civilian and military.

In studying the data in this table, it is apparent that from the first to the second fiscal year (quarters 1-4 to quarters 5-8), there was a moderately large increase in the labor cost index for both the civilian and military. There was an even more marked upturn in the military labor cost index in the third year (quarter 9-3). This is the result of the FY 82 military payraise of over 11% compared to the substantially smaller civilian pay raise.

The cost indices shown in Table 4-1 were used as the denominator for the ratio:

$$\text{Labor Cost (Constant Dollars)} = \frac{\text{Labor Cost in Current Dollars}}{\text{Labor Cost Index}}$$

This formula was used to compute the constant dollar values of the cost of labor input.

TABLE 4-1

CIVILIAN AND MILITARY LABOR COST INDEX

	CIVILIAN		MILITARY	
QTR	ANNUAL SALARY (GS-8/1)	LABOR COST INDEX	ANNUAL BASE PAY (E-6 over 6)	LABOR COST INDEX
1	$15423	1.00	$ 9432	1.00
2	$15423	1.00	$ 9432	1.00
3	$15423	1.00	$ 9432	1.00
4	$15423	1.00	$ 9432	1.00
5	$16826	1.09	$10536	1.12
6	$16826	1.09	$10536	1.12
7	$16826	1.09	$10536	1.12
8	$16826	1.09	$10536	1.12
9	$17634	1.14	$12276	1.30
10	$17634	1.14	$12276	1.30
11	$17634	1.14	$12276	1.30
12	$17634	1.14	$12276	1.30

SOURCE: CIVILIAN ANNUAL SALARY TAKEN FROM FEDERAL EMPLOYEE GENERAL SCHEDULE.
MILITARY ANNUAL BASE PAY TAKEN FROM MILITARY PAY SCHEDULES.

The Washington facility reported labor cost based on the Federal Employee General Schedule. For the purpose of this analysis the labor cost data was extracted from the Radiac Maintenance Workload Reports. Referring to Appendices B and C, it can be seen that there are several areas of cost reported. In this analysis, only the cost for repair and calibration personnel was used. This information is reflected in Table 4-2. The decision was made to use cost for repair and calibration personnel only which includes both the direct labor cost and indirect labor cost.

TABLE 4-2

CIVILIAN LABOR COST DATA

QTR	OUTPUT	CUR $	COST INDEX	CON &	COST PER UNIT OF OUTPUT CUR $	COST PER UNIT OF OUTPUT CON $
1	400	$18649	1.00	$18649	$46.62	$46.62
2	437	$16007	1.00	$16007	$36.63	$36.63
3	428.5	$16925	1.00	$16925	$39.50	$39.50
4	376	$14102	1.00	$14102	$37.51	$37.51
5	283.5	$21618	1.09	$19833	$76.25	$69.95
6	504	$20493	1.09	$18801	$40.66	$37.30
7	501	$14776	1.09	$13556	$29.49	$27.06
8	400	$14171	1.09	$13000	$35.43	$32.50
9	364	$13313	1.14	$11678	$36.57	$32.08
10	387	$15460	1.14	$13561	$39.95	$35.04
11	592	$16838	1.14	$14770	$28.44	$24.95
12	470	$14115	1.14	$12382	$30.03	$26.34
MEANS					$39.76	$37.13

SOURCE: RADIAC MAINTENANCE WORKLOAD REPORTS
LEGEND: QTR (QUARTER)
CUR $ (CURRENT DOLLAR, COST OF LABOR: ACTUAL GRADES)
CON $ (CONSTANT DOLLAR, COST OF LABOR: ACTUAL GRADES)

Military labor cost in current dollars was determined by using the NEBC model. Cost was extracted from the cost tables for each paygrade reported onboard. The sum of these costs for each individual resulted in the quarterly labor cost in current dollar, as shown in Table 4-3.

The efficiency of the two repair facilities is shown in the last columns of Tables 4-2 and 4-3. A plot of these data is shown in Figure 4-1.

It appears from Tables 4-2 and 4-3 that the cost of direct labor, in both current and constant dollars, was generally greater for the civilian facility due to the greater number of civilian workers. However, the per person cost

TABLE 4-3

MILITARY LABOR COST DATA

QTR	OUTPUT	CUR $	COST INDEX	CON $	COST PER UNIT OF OUTPUT CUR $	CON $
1	122.4	$12766	1.00	$12766	$104.30	$104.30
2	113	$12766	1.00	$12766	$112.97	$112.97
3	201	$12766	1.00	$12766	$ 63.51	$ 63.51
4	171	$12766	1.00	$12766	$ 74.65	$74.65
5	168	$13437	1.12	$11997	$ 79.98	$ 71.41
6	93.6	$13437	1.12	$11997	$143.56	$128.18
7	173	$14370	1.12	$12830	$ 83.06	$ 74.16
8	153	$20087	1.12	$17934	$131.29	$117.22
9	152.5	$24135	$1.30	$18565	$158.26	$121.74
10	122.7	$24135	$1.30	$18565	$196.70	$151.30
11	200	$26090	$1.30	$20069	$130.45	$100.34
12	171.2	$26090	$1.30	$20069	$152.39	$117.22
MEANS					$119.26	$103.08

SOURCE: NAVY ENLISTED BILLET COST MODEL
LEGEND: QTR (QUARTERS)
CUR $ (CURRENT DOLLAR, COST OF LABOR: ACTUAL GRADES)
CON $ (CONSTANT DOLLAR, COST OF LABOR: ACTUAL GRADES)

was actually greater for the military workers. For example, the individual cost for quarter 1 was $4662 and $6383 for civilian and military, respectively. Although this seems to contradict the relative costs presented in Table 4-1, the difference lies in the basis of the costs. The data shown in Table 4-1 represent base salary or base pay only. Civilian current dollar costs shown in Table 4-2 are the total labor costs reported by the repair facility on the Radiac Maintenance Workload Report for that quarter, including overhead elements. Military current dollar costs shown in Table 4-3 are the life cycle billet cost amounts, including allowances for all the items described in Section A, above.

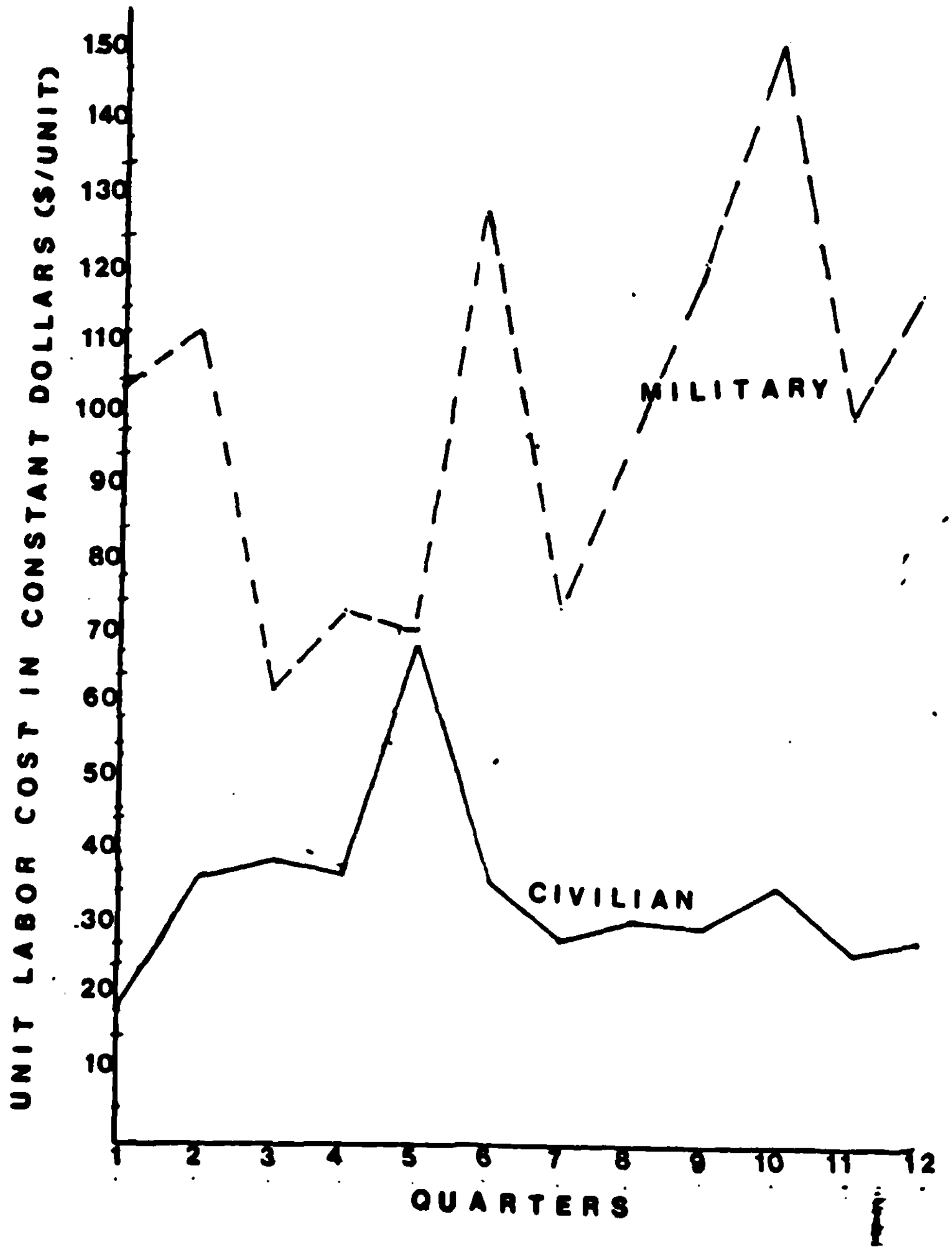

Figure 4-1 Output Cost

These two tables and the figure show cost per unit of output varying for each facility over the course of time studied. The average cost per unit of output for the civilians was $37.13 in constant dollars. The average cost per unit for the military in constant dollars was $1Ø3.Ø8. Overall, the civilian labor force was more than 2.7 times as efficient as the military labor force. Not surprisingly, the comparison between the efficiency of the two labor forces shown in Figure 4-1 is very similar to that shown in Figure 3-2, except that the disparity between civilian and military is even greater than in the earlier comparison.

It should be noted that cost comparisons between the civilian and military workforces should be made with some caution because of differences in the data. As noted above in Section A, labor cost for both labor forces included overhead cost elements, however the two models used in estimating overhead costs for civilian and for military were dissimilar.

C. COMPARISON OF COMPENSATION

To further the analysis of the operational efficiency of the repair facilities, an analysis of hours worked was made. The cost data resulting from this analysis will subsequently be matched with cost per unit of output.

"Hours worked" (HW) are those hours actually spent at work. "Hours paid: (HP) are those hours at work plus training, leave, holidays and diversion time. These correspond, respectively, to the concepts of "productive labor" and

"available labor" used in the preceeding chapter. A comparison was made to analyze the difference in hourly compensation between civilian and military. These data are shown in Tables 4-4 and 4-5 for the civilian and military personnel. Table 4-4 shows the actual hours worked as recorded for the civilians. Table 4-5 shows, for the military, annual hours available for work (hours paid); estimated diversion time, and the resulting estimate of hours worked. Both tables show, for their respective labor forces, annual compensation and compensation per man-hour for each fiscal year. The compensation figures are shown both in current and constant dollars.

These tables indicate that the compensation per man-hour was significantly greater for the military workforce; approximately fifty per cent greater. Of course, the same cautions that applied to the civilian-to-military comparisons of productivity in Chapter III and to the comparisons of labor cost per unit of output discussed earlier in this chapter also apply here, as this comparison is based on the same data and thus has the same imperfections.

D. COST AND PRODUCTIVITY

When the output per man-hour data from Chapter III is matched with the compensation per man-hour above, a comparison of cost and productivity can be made for each facility. Table 4-6 presents in fiscal year aggregates the average output per manhour and compensation per manhour in constant dollars for civilian and military personnel.

TABLE 4-4

COMPENSATION PER HOUR WORKED (CIVILIAN)

	FY 80	FY 81	FY 82
ANNUAL HOURS WORKED	$ 5928	$ 6843	$ 5325
ANNUAL COMPEN-SATION (CUR $)	$65683	$71058	$59726
ANNUAL COMPEN-SATION (CON $)	$65683	$65190	$52391
COMPEN-SATION PER MAN-HOUR (CUR $)	$11.08	$10.38	$11.22
COMPEN-SATION PER MAN-HOUR (CON $)	$11.08	$ 8.53	$ 9.84

SOURCE: ANNUAL HOURS WORKED FROM TABLE 3-5 (STANDARDIZED MAN-HOURS)
ANNUAL COMPENSATION FROM TABLE 4-2

LEGEND: CUR $ (CURRENT DOLLARS)
CON $ (CONSTANT DOLLARS)
LABOR HOURS AND COMPENSATION WERE SUMMED FOR EACH YEAR

TABLE 4-5

COMPENSATION PER HOUR WORKED (MILITARY)

	FY 8∅	FY 81	FY 82
HOURS PAID	416∅*	468∅**	624∅***
LESS: DIVERSION	838	943	1257
EQUALS: ANNUAL HOURS WORKED	3322	3737	4983
ANNUAL COMPENSATION (CUR $)	$51∅64	$61331	$1∅∅45∅
ANNUAL COMPENSATION (CON $)	$51∅64	$5476∅	$ 77269
COMPENSATION PER MAN-HOURS (CUR $)	$15.37	$16.41	$2∅.16
COMPENSATION PER MAN-HOUR (CON $)	$15.37	$14.65	$15.51

SOURCE: ANNUAL HOURS FROM TABLES 3-2 AND 3-4
ANNUAL COMPENSATION FROM TABLE 4-3

LEGEND: * (2 WORKERS)
** (AVERAGE OF 2.25 WORKERS
*** (3 WORKERS)
CUR $ (CURRENT DOLLARS)
CON $ (CONSTANT DOLLARS)

TABLE 4-6

PRODUCTIVITY AND COMPENSATION PER MAN-HOUR

	Civilians		Military	
FY	Productivity	Cost/Hour	Productivity	Cost/Hour
80	.277	$11.08	.183	$15.36
81	.247	$ 9.53	.157	$14.65
82	.341	$ 9.84	.130	$15.50
80-82	.284	$10.13	.153	$15.27
Cost/Unit	$35.63		$99.44	

SOURCE: TABLES 3-5, 3-7, 4-4, AND 4-5
LEGEND: PRODUCTIVITY (STANDARD CALIBRATION UNITS PER HOUR)
COST/HOUR WORKED (COST PER HOUR WORKED IN CONSTANT DOLLARS)
CIVILIAN BASED ON STANDARDIZED MAN-HOUR ESTIMATES; MILITARY BASED ON ADJUSTED MAN-HOUR ESTIMATES.

From fiscal year 1980 to 1981 there was a slight decrease in productivity for the civilian personnel. The comparison between FY80 and FY82 shows a 23% increase in productivity in FY82 over FY80 and an 11% decrease in compensation (constant dollar). The military output gradually dropped over the period covered by the study. Between the fiscal years 1980 and 1982 productivity decreased 29% while compensation rose slightly. The decrease in productivity apparently was the result of the third technician being added in the eighth quarter. There was not a corresponding increase in workload associated with the additional manning, therefore productivity was reduced.

When the data for civilian and military are compared to each other the only similarity is the FY81 decrease in productivity. In neither case did the collected data give any

explanation for the reduced level of productivity in FY 81. Looking at the period of time covered by this study, the military-manned facility overall showed low productivity. The cost associated with the military level of output seems quite high, but one must remember that labor cost was based on the life cycle cost concept. According to the data analysis the civilian operation had nearly twice the level of productivity that the military-manned facility had. At the same time, the military labor cost was fifty per cent greater than that of the civilian facility. As a result, the per unit cost for calibrating a radiac in Rota was nearly three times greater than it was in Washington.

E. SUMMARY

This chapter has reviewed and analyzed labor cost for both labor forces in terms of current and constant dollars. The analysis showned that the military had a greater per person labor cost.

Next, labor cost was compared with productivity levels to determine the actual cost of output per unit. The calculated cost showed that the average cost per unit for the civilians in constant dollars was $35.63 and $99.44 for the military. This analysis showed the civilian operation to be more efficient than the military.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Throughout the course of the study, factors were discussed which contributed to the overall calculated cost and level of productivity achieved at Navy Radiac Repair Facilities (RRFs). Foremost among these factors was whether the calibration work was performed by civilian or military technicians. In order to study the hypothesis that the labor force did affect productivity, data were collected for two forces: civilian at RRF Washington and military at RRF Rota.

At the beginning of the study, there was no reason to believe that either repair facility labor force would be significantly better than the other. However, as the study developed, it became more apparent that staffing did have a bearing on the efficiency of the operation of the repair facilities. In Chapter III, it was shown that the facility manned by civilians had nearly twice the productivity in units calibrated per man-hour as did the facility manned by military.

The difference in observed productivity may have been due in part to workforce differences. Specifically, that it may have been due to differences in skill and familiarity with the equipment and to differences in assigned tasks. The civilians had more specific work experience repairing

radiacs than the military personnel. This experience is due in part to the relative stability of the civilian workforce as compared to the frequent duty rotation of the military. As a general rule, the civilians were not assigned tasks other than the ones for which they were hired. It was quite possible that the military personnel was assigned to watch-standing, shore patrol, mess cooking, and other duties all of which could take a considerable amount of what was presumed to be "productive" time.

It was also theorized that the difference in productivity may have, in part, been due to possible differences in work-loading. Although data on workloading was not present in sufficient detail to explore this hypothesis, it did seem plausible based on the nature of the repair facilities' customers. RRF Washington serviced shore-based activities which did not have fluctuations in their operating schedules. RRF Rota's major customers were operating ships and aircraft squadrons which frequently had changes in operating schedules. The Washington facility could schedule the arrival of equipment whereas the Rota facility received the majority of its work when the ships and aircrafts were in port.

The analysis continued, in Chapter IV, with an examination of the labor cost per unit output for the two facilities. Labor cost was found significantly higher for the military. The overall cost per unit of output (in constant 1980 dollars) was $35.63 and $99.44, for the civilian and

military facilities, respectively. This was consistent with the findings in Chapter III which had shown a much lower level of productivity for the military.

The analyses in Chapter III and IV indicated that the civilian-manned repair facility was far more efficient than was the military-manned facility.

B. RECOMMENDATIONS

As this analysis developed, it became apparent that data on workloading could serve as a vital link. Without accurate and detailed workloading data the results of the analysis may be misleading.

A detailed accounting of weekly throughput based on type of equipment would benefit future studies since all equipments do not require the same amount of time for calibrations. It is assumed that the less complex equipments would require less time. Having access to this information would show whether one or both facilities had equipments which took a long time to calibrate, a short period of time to calibrate, or an even mixture. It would also be helpful to determine if benchmark calibration times exist for the various types of radiacs and determine if actual calibration times are recorded on equipment maintenance records.

At the same time a determination should be made as to whether the repair facilities are practicing stockpiling. Stockpiled equipments could be identified by checking the arrival and departure dates on the maintenance records.

Review of the maintenance records and Radiac Maintenance Workload Reports would show peaks and valleys which could be indicative of overloading during some periods and not others.

Collecting this additional information would allow a more complete analysis and a better explanation for the levels of productivity achieved by each workforce.

Reported data should be audited for accuracy. It is recommended that civilian man-year data be audited against a random sampling of time and attendance records. This would show if the time being reported actually equaled the time worked.

Actual reporting of military labor input data would aid future researchers as well as NAVELEX to see the true level of input commensurate with the level of output. Current method of estimating labor input for military is much too subjective and leaves room for error. Having this information would also help to determine the cost of doing business at RRF Rota.

The findings in Chapter III showed the civilians to be nearly twice as productive as the military. There was no one apparent reason for this outcome because each workforce was made up of highly skilled technicians. Because the reason was not obvious additional work should be done to see what affects the "learning curve" phenomenon had on the two workforces. From the results obtained it would seem that the "learning curve" had more direct effect on the military

personnel. This is thought to be the case since it was determined earlier in the study that the cvilians had an average of fifteen years in the Radiac Program. It is recommended that a literature search be made for studies done with similar types of work.

This study alone is not enough to recommend that all RRFs be manned with civilian personnel. The results do warrant a thorough study be made of the cost-efficiency of employing civilian personnel at the two repair facilities which have military personnel.

It is also recommended that consideration be given to improving this study. Perhaps this could be done by using the life cycle cost for the civilian billets as well. This would make the cost data more comparable because similar cost elements would be considered for civilian and military alike.

APPENDIX A

LOCATION OF RADIAC COORDINATORS, AND THEIR AREAS OF RESPONSIBILITY

LOCATION OF RADIAC COORDINATOR	AREA OF RESPONSIBILITY
Portsmouth Naval Shipyard Portsmouth, NH	First Naval District North of Boston; NPTU W. Milton, NY; NPTU Windsor, CT
Naval Submarine Support Facility New London Groton, CT	First Naval District In and South of Boston, Third Naval District (Connecticut Only)
Naval Electronic Systems Engineering Center Portsmouth, VA	U.S. Naval Forces Europe and Fifth Naval District
Naval Electronic Systems Security Engineering Center Washington, DC	Naval District Washington
Naval Electronic Systems Engineering Center Charleston, SC	Sixth, Eighth, Fifteenth Naval Districts, Charleston, Caribbean Area, and Guantanamo Bay Area
Naval Electronic Systems Engineering Center San Diego, CA	Eleventh Naval District
Long Beach Naval Shipyard Long Beach, CA	Long Beach Naval Shipyard
Naval Electronic Sysems Engineering Center Vallejo, CA	Mare Island Naval Shipyard Twelfth Naval District
Puget Sound Naval Shipyard Bremerton, WA	Thirteenth Naval District
Naval Shore Electronics Engineering Activity, Pacific Pearl Harbor Naval Shipyard Pearl Harbor, HI	Fourteenth Naval District Japan, Okinawa, Korea, Taiwan, US Forces Marianas, US Forces Philippines Southeast Asia

(SOURCE: NAVELEX INSTRUCTION 9673.5D)

RADIAC MAINTENANCE WORKLOAD REPORT

NAVELEX 9673/4 (Rev 6-81)

This report contains: ( ) estimated costs, ( ) actual costs (check one). 3rd QTR FY 80

1. PERSONNEL EMPLOYED AND COST PER PERSON:
   a. MANAGERS (GRADED)

TITLE/FUNCTION*	GRADE	NAME OF ACTIVITY	MAN YEARS (IN 100th)	**LABOR	OVERHEAD ($ IN DOLLARS)	SUBTOTAL
Rad Coord (A)	GS-11	NAVSEEACTPAC	.25	4,798	2,584	7,382
		SUBTOTAL				

   b. REPAIR AND CALIBRATION PERSONNEL (GRADED AND UNGRADED)

TITLE/FUNCTION*	NAME OF ACTIVITY	MAN YEARS (IN 100th)	**LABOR	OVERHEAD ($ IN DOLLARS)	SUBTOTAL
Elect. Mech. (A)	PHNSY	2.40	63,158	45,360	108,518
Elect. Mech. (B)	PHNSY	0.20	5,263	3,780	9,043
Elect. Mech. (C)	PHNSY	0.40	10,526	7,560	18,086
	SUBTOTAL	3.00	78,947	56,700	135,647

(COSTS CHARGED TO FUNCTION*A, B AND C SHOULD BE SEPARATED AND NOTED BY EITHER A, B OR C - FUNCTION A COSTS TO BE INCLUDED IN PARAGRAPH 4).

2. TAD AND TRAINING
   LIST TAD TRAINING WITH DOLLARS ALLOCATED TO EACH FUNCTION*(EXPLAIN BRIEFLY HOW IT BENEFITED THE RADIAC PROGRAM BY FUNCTION*.)

A.	NRC Refresher Training	$1,005
A.	Westpac Radiac Program Review	$1,451
	SUBTOTAL	$2,456

3. MATERIAL (IN DOLLARS) BY FUNCTION*

A.	15,780
B.	1,400
C.	2,680
SUBTOTAL	19,860

4. TOTAL COST CHARGED TO NAVELEX FOR QUARTER
   SUBTOTAL 1 (MINUS RADIAC COORDINATOR)+2A+3A+ 126,754

5. WORKLOAD
   a. MAINTENANCE WORK BY FUNCTION*

NOMENCLATURE RADIAC EQUIPMENT	QUANTITY OU	QUANTITY NON-OU	CALIBRATION UNITS
(ATTACH ADDITIONAL SHEETS TO ACCOMMODATE LOCAL WORKLOAD. SEE ENCLOSURE (1) TO THIS FORM.)	(SEE NOTE 1) A. 2250 B. 24 C. 0	(SEE NOTE 2) A. 442 B. 0 C. 0	(SEE NOTES 3-9) A. 770 B. 24 C. 165.9

*FUNCTION
- A. NAVELEX HQ FUNDED
- B. CUSTOMER FUNDED
- C. CROSS SERVICE FUNDED

NOTES
1. OPERATIONAL USE PRIORITIES 1-9 LISTED IN NAVELEXINST 9673.5( )
2. NON OPERATIONAL USE PRIORITIES 10-13 LISTED IN NAVELEXINST 9673.5( )
3. RATEMETER PLUS DETECTOR EQUAL ONE CALIBRATION UNIT
4. 5 DOSIMETER CHARGERS EQUAL ONE CALIBRATION UNIT
5. 50 Q.F. DOSIMETERS EQUAL ONE CALIBRATION UNIT
6. 5 DETECTORS (DT+304) EQUAL ONE CALIBRATION UNIT
7. 1 TLD READER EQUALS THREE CALIBRATION UNITS
8. 25 TLD's EQUAL ONE CALIBRATION UNIT
9. OTHER EQUIPMENTS EQUAL ONE CALIBRATION UNIT EACH

**IF LABOR AND OVERHEAD ARE NOT SEPARATED IN EXPENDITURE REPORT, INDICATE COMBINED FIGURE IN SUB-TOTAL COLUMN.

3rd QTR FY 1981
RADIAC EQUIPMENT PROCESSED

EQUIPMENT	NAVY				NON-NAVY
	NAVELEX $'s		CUSTOMER $'s		ISSA $'s
	(1-9)	(10-13)	(1-9)	(10-13)	
AN/PDR-27( )					
AN/PDR-43( )					
AN/PDR-45( )					
AN/PDR-54( )					
AN/PDR-56( )					
AN/PDR-60( )					
AN/PDR-65					
AN/PDR-70					
CP-95( )/PD					
CP-792( )/UD					
CP-1112					
DT-304					
DT-526					
GAMMA ALARM 492					
IC/T2-PAB					
IM-9( )/PD					
IM-93( )/PD					
IM-143( )/PD					
PP-4276( )/PD					
RM-3C( )w/DETECTOR					
RT-1					
IM-174( )/PD					
Qty/Cal. units					

Enclosure (1) to NAVELEX 9673/4
(Rev 6-81)

APPENDIX C

DATA

WASHINGTON

QTR	MANAGER MY	MANAGER L&O	WORKERS MY	WORKERS L&O	TAD & TRNG	MATERIAL	CAL UNITS
1	.24	$6.7	.74	$18.6	0	$1.2	400
2	.24	$6.7	.75	$16.0	0	$1.8	437
3	.24	$6.7	.74	$16.9	$1.5	$1.2	428.5
4	.23	$6.3	.62	$14.0	$ .7	$4.5	376
5	.20	$5.8	.98	$21.6	0	$3.5	283.5
6	.24	$6.8	.96	$20.5	0	$1.3	504
7	.23	$6.8	.68	$15.0	0	$6.2	501
8	.24	$6.5	.67	$14.1	0	$3.3	400
9	.24	$6.3	.63	$13.0	0	$ .3	364
10	.12	$3.6	.63	$16.0	$1.0	$2.3	387
11	.14	$4.4	.69	$17.0	$1.7	$1.0	592
12	.13	$4.1	.61	$14.1	$.03	$11.0	470

ROTA

QTR							
1	.25	-	.25	-	-	$ .7	122.3
2	.25	-	.25	-	-	$1.5	113
3	.25	-	.25	-	-	$ .7	201
4	.25	-	.25	-	-	$2.2	171
5	.25	-	.25	-	-	$2.7	168
6	.25	-	.25	-	-	$1.8	93.6
7	.25	-	.25	-	-	$2.4	173
8	.25	-	.50	-	-	$2.0	153
9	.25	-	.50	-	-	$4.9	152.5
10	.25	-	.50	-	-	$1.8	122.7
11	.25	-	.50	-	-	$2.6	200
12	.25	-	.50	-	-	$6.2	171.2

SOURCE: RADIAC MAINTENANCE WORKLOAD REPORTS

LEGEND: MY (MAN-YEAR)
L&O (LABOR AND OVERHEAD)
TAD & TRNG (TEMPORARY ADDITIONAL DUTY AND TRAINING)
CAL UNITS (CALIBRATION UNITS)
DOLLARS EXPRESSED IN THOUSANDS

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7. NAVELEX INSTRUCTION 9673.5D, "Maintenance, Possession, and User Responsibilities for Radiac Equipment," September, 1978.

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11. NAVELEX INTERNAL SUMMARY SHEET (Unnumbered informal worksheets, one for each quarter)

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